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What is claimed is:

1. A method of encoding a plurality of predefined codes into a search key, the method comprising:

    a) producing a Prefix Node Bit Array (PNBA) having a plurality of bit positions corresponding to possible bit combinations of a bit string having a length equal to or less than the longest predefined code in said plurality of said pre-defined codes such that said bit positions are arranged by the lengths of said possible bit combinations and by numeric value of said possible bit combinations; and

    b) setting bits active in bit positions which correspond to bit combinations of said possible bit combinations identified by said pre-defined codes.

2. The method claimed in claim 1 wherein producing comprises arranging said bit positions in order by ascending lengths of corresponding said possible bit combinations.

3. The method claimed in claim 2 wherein producing comprises further arranging said bit positions in order by ascending numeric value of corresponding said possible bit combinations.

4. The method claimed in claim 1 further comprising producing a next hop array associating bit positions of said PNBA which have active bits with routing information for use by a router to route a packet.

5. The method claimed in claim 1 wherein producing comprises producing a plurality of PNBAs, each PNBA corresponding to a sub-group of bits of said pre-defined codes.

6. The method claimed in claim 5 further comprising producing an External Subtree Root Bit Array (ESRBA) for each PNBA, said ESRBA

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having bit positions corresponding to possible further subgroups of bits of said pre-defined codes.

7. The method claimed in claim **6** further comprising producing a plurality of pages, each page comprising a plurality of PNBA-ESRBA pairs.

5   8. The method claimed in claim **6** further comprising producing a next hop array associating bit positions of said PNBA which have active bits with routing information for use by a router to route a packet.

9. The method claimed in claim **8** further comprising associating with each of said PNBAs a next hop pointer pointing to a position in said
10   next hop array at which next hop information associated with a first active bit of said PNBA is located.

10. The method claimed in claim **9** further comprising arranging said plurality of PNBAs into a plurality of respective pages, each page comprising a PNBA, an associated ESRBA, an associated next hop
15   pointer and a next page pointer pointing to a next page in said plurality of respective pages to be searched.

11. An apparatus for encoding a plurality of predefined codes into a search key, the apparatus comprising:

a)   means for producing a Prefix Node Bit Array (PNBA) having a
20   plurality of bit positions corresponding to possible bit combinations of a bit string having a length equal to or less than the longest predefined code in said plurality of said pre-defined codes such that said bit positions are arranged by the lengths of said possible bit combinations and by numeric value of said bit combinations;
25   and

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b)   means for setting active bits in bit positions which correspond to bit combinations of said possible bit combinations identified by said pre-defined codes.

12.   An apparatus for encoding a plurality of predefined codes into a search key, the apparatus comprising a processor circuit configured to:

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a)   produce a Prefix Node Bit Array (PNBA) having a plurality of bit positions corresponding to possible bit combinations of a bit string having a length equal to or less than the longest predefined code in said plurality of said pre-defined codes such that said bit positions are arranged by the lengths of said possible bit combinations and by numeric value of said bit combinations, and

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b)   set active bits in bit positions which correspond to bit combinations of said possible bit combinations identified by said pre-defined codes.

13.   The apparatus claimed in claim 12 wherein said processor circuit is configured to arrange said bit positions in order by ascending lengths of corresponding said possible bit combinations.

15

14.   The apparatus claimed in claim 13 wherein said processor circuit is configured to further arrange said bit positions in order by ascending numeric value of corresponding said possible bit combinations.

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15.   The apparatus claimed in claim 12 wherein said processor circuit is configured to produce a next hop array associating bit positions of said PNBA which have active bits with routing information for use by a router to route a packet.

25

16.   The apparatus claimed in claim 12 wherein said processor circuit is configured to produce a plurality of PNBAs, each PNBA corresponding to a sub-group of bits of said pre-defined codes.

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17. The apparatus claimed in claim **16** wherein said processor circuit is configured to produce an External Subtree Root Bit Array (ESRBA) for each PNBA, said ESRBA having bit positions corresponding to possible further subgroups of bits of said pre-defined codes.

5   18. The apparatus claimed in claim **17** wherein said processor circuit is configured to produce a plurality of pages, each page comprising a plurality of PNBA-ESRBA pairs.

19. The apparatus claimed in claim **17** wherein said processor circuit is configured to produce a next hop array associating bit positions of said

10   PNBA which have active bits with routing information for use by a router to route a packet.

20. The apparatus claimed in claim **19** wherein said processor circuit is configured to associate with each of said PNBAs a next hop pointer pointing to a position in said next hop array at which next hop

15   information associated with a first active bit of said PNBA is located.

21. The apparatus claimed in claim **20** wherein said processor is configured to arrange said plurality of PNBAs into a plurality of respective pages, each page comprising a PNBA, an associated ESRBA, an associated next hop pointer and a next page pointer

20   pointing to a next page in said plurality of respective pages to be searched.

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22. A method of locating, in a list of pre-defined codes, a longest code matching a given code, the method comprising

   a) producing a search mask encoding at least one portion of said given code; and

   b) comparing said search mask to a search key having a Prefix Node Bit Array (PNBA) in which a bit is set active in at least one of a plurality of bit positions corresponding to possible bit combinations of bits in a bit string having a length equal to or less than the longest predefined code in said plurality of said pre-defined codes and arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations, to identify a common active bit position in said search key and said search mask corresponding to a one of said pre-defined codes having a length greater than all others of said pre-defined codes which correspond to common active bit positions.

23. The method claimed in claim 22 wherein producing comprises producing a Prefix Node Bit Array (PNBA) mask having bit positions corresponding to possible bit combinations in said given code and wherein said bit positions are arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations.

24. The method claimed in claim 23 wherein comparing comprises ANDing said PNBA mask with a search PNBA of said search key to produce a resultant PNBA.

25. The method claimed in claim 24 wherein comparing comprises determining a highest bit position in said resultant PNBA in which a bit is set.

26.   The method claimed in claim **25** wherein comparing further comprises selecting as said longest code a pre-defined code corresponding to said highest bit position in said resultant PNBA.

27.   A method of locating next hop information for a packet having a destination address comprising the method claimed in claim **25** in which the destination address is the given code and further comprising locating a position in a next hop array associating next hop information with active PNBA bit positions of the search PNBA, corresponding to said highest bit position in said resultant PNBA.

28.   The method claimed in claim **22** wherein producing comprises producing a plurality of Prefix Node Bit Array (PNBA) masks having bit positions corresponding to possible bit sub-combinations in said given code and wherein said bit positions are arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations.

29.   The method claimed in claim **28** wherein comparing comprises ANDing at least one of said PNBA masks with a search PNBA encoding possible bit sub-combinations of said pre-defined codes to produce at least one resultant PNBA.

30.   The method claimed in claim **29** wherein comparing comprises determining a highest bit position in said at least one resultant PNBA in which a bit is set.

31.   The method claimed in claim **30** wherein comparing further comprises selecting as said longest code a code having a sub-combination corresponding to said highest bit position in said at least one resultant PNBA.

32.   A method of locating next hop information for a packet having a destination address the method comprising the method claimed in

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claim **31** in which the destination address is the given code and further comprising locating a position in a next hop array associating next hop information with active PNBA bit positions of the search PNBA, by determining a highest numbered bit position in said resultant PNBA and summing all of the active bits in the search PNBA in positions of the search PNBA less than a position with the same number as said highest numbered bit position in said resultant PNBA to produce a PNBA sum and adding said PNBA sum to a value representing a next hop pointer associated with said search PNBA to produce a next hop value identifying said position in said next hop array.

33. The method claimed in claim **30** wherein comparing further comprises determining whether or not any longer matching pre-defined code is encoded.

34. The method claimed in claim **33** wherein comparing comprises comparing said PNBA mask with at least one search PNBA associated with a search page.

35. The method claimed in claim **34** wherein comparing comprises determining a next search page to use to seek a longer matching pre-defined code.

36. The method claimed in claim **35** wherein determining a next search page comprises producing an External Subtree Root Bit Array (ESRBA) mask for each PNBA mask, wherein each ESRBA mask has 2^k bit position where $k =$ the number of bits by which said given code is divided into sub prefixes and a bit position P of said each ESRBA mask is set active according to the following expression:

$$P = \text{associated PNBA mask bit position} - 2^{k-1}$$

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37. The method claimed in claim **36** further comprising ANDing one of said ESRBA masks with an ESRBA associated with a said at least one of said PNBA masks to produce a resultant ESRBA.

38. The method claimed in claim **37** further comprising determining a set bit position in said resultant ESRBA in which a bit is set and summing all of the active bits in the search ESRBA in positions of the search ESRBA less than a position with the same number as said set bit position, to produce an ESRBA sum and adding said ESRBA sum to a value representing a next page pointer associated with said search ESRBA to produce a next page value identifying a next page to use to continue searching for a longer matching pre-defined code.

39. A method of locating next hop information for a packet having a destination address, the method comprising the method claimed in claim **38** in which the destination address is the given code and further comprising locating a position in a next hop array associating next hop information with active PNBA bit positions of the search PNBA and sorted according to corresponding to said active bit positions, corresponding to said highest bit position in said resultant PNBA.

40. The method claimed in claim **34** wherein comparing comprises determining a next PNBA to use to seek a longer matching pre-defined code.

41. The method claimed in claim **40** wherein determining a next PNBA comprises producing an External Subtree Root Bit Array (ESRBA) mask for each PNBA mask, wherein each ESRBA mask has 2^k bit position where k = the number of bits by which said given code is divided into sub prefixes and a bit position P of said each ESRBA mask is set active according to the following expression:

$$P = \text{associated PNBA mask bit position} - 2^{k-1}$$

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42. The method claimed in claim **41** further comprising ANDing one of said ESRBAs with an ESRBA associated with a current PNBA to produce a resultant ESRBA.

43. The method claimed in claim **42** further comprising determining a set bit position in said resultant ESRBA in which a bit is set active and summing the bits of any previous search ESRBAs in the page to produce an ESRBA previous sum, summing the bits of a preset search ESRBA up to the same position as said set bit position, to produce a present ESRBA sum and adding the ESRBA previous sum to the ESRBA preset sum plus **1** to produce a PNBA-ESRBA indicator representing a next PNBA-ESRBA pair to use for searching.

44. The method claimed in claim **43** further comprising determining a next page with which said next PNBA-ESRBA pair is associated according to the relation:

$$\text{Next page} = \text{next page pointer in current page} + \left\lceil \frac{r - u - 1}{u} \right\rceil$$

where

$r =$ said next PNBA-ESRBA indicator

$u =$ the number of PNBA-ESRBA pairs associated with a page

when

$r > u$.

45. A method of locating next hop information for a packet having a destination address, the method comprising the method claimed in claim **43** in which the destination address is the given code and further comprising locating a position in a next hop array associating next hop

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information with active PNBA bit positions of each search PNBA by summing all of the bits of all previous search PNBAs in a page to produce a PNBA previous sum, summing all of the bits of a present search PNBA associated with said page up to a position where the bit *less than the position* is set to produce a present PNBA sum and adding the PNBA previous

5 sum with the PNBA preset sum plus a value representing a next hop pointer associated with the page associated with the preset PNBA to produce next hop array position value identifying a next hop array position in a next hop array at which said next hop information is

10 stored.

46. An apparatus for locating, in a list of pre-defined codes, a longest code matching a given code, the apparatus comprising:

a) means for producing a search mask encoding at least one portion of said given code; and

15 b) means for comparing said search mask to a search key having a Prefix Node Bit Array (PNBA) in which a bit is set active in at least one of a plurality of bit positions corresponding to possible bit combinations of bits in a bit string having a length equal to or less than the longest predefined code in said plurality of said

20 pre-defined codes and arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations, to identify a common active bit position in said search key and said search mask corresponding to a one of said pre-defined codes having a length greater than all others of said pre-defined

25 codes which correspond to common active bit positions.

47. A apparatus for locating, in a list of pre-defined codes, a longest code matching a given code, the apparatus comprising a processor circuit configured to:

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a) produce a search mask encoding at least one portion of said given code; and

b) compare said search mask to a search key having a Prefix Node Bit Array (PNBA) in which a bit is set active in at least one of a plurality of bit positions corresponding to possible bit combinations of bits in a bit string having a length equal to or less than the longest predefined code in said plurality of said pre-defined codes and arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations, to identify a common active bit position in said search key and said search mask corresponding to a one of said pre-defined codes having a length greater than all others of said pre-defined codes which correspond to common active bit positions.

48. The apparatus claimed in claim 47 wherein said processor circuit is configured to produce a Prefix Node Bit Array (PNBA) mask having bit positions corresponding to possible bit combinations in said given code and wherein said bit positions are arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations.

49. The apparatus claimed in claim 48 wherein said processor circuit is configured to AND said PNBA mask with a search PNBA of said search key to produce a resultant PNBA.

50. The apparatus claimed in claim 49 wherein said processor circuit is configured to determine a highest bit position in said resultant PNBA in which a bit is set.

51. The apparatus claimed in claim 50 wherein said processor circuit is configured to select as said longest code a pre-defined code corresponding to said highest bit position in said resultant PNBA.

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52. A apparatus for locating next hop information for a packet having a destination address, the apparatus comprising the apparatus claimed in claim **50** in which the destination address is the given code and wherein said processor circuit is configured to locate a position in a

5 next hop array associating next hop information with active PNBA bit positions of the search PNBA, corresponding to said highest bit position in said resultant PNBA.

53. The apparatus claimed in claim **47** wherein said processor circuit is configured to produce a plurality of Prefix Node Bit Array (PNBA)

10 masks having bit positions corresponding to possible bit sub-combinations in said given code and wherein said bit positions are arranged by the lengths of said possible bit combinations and by numeric values of said bit combinations.

54. The apparatus claimed in claim **53** wherein said processor circuit is

15 configured to AND at least one of said PNBA masks with a search PNBA encoding possible bit sub-combinations of said pre-defined codes to produce at least one resultant PNBA.

55. The apparatus claimed in claim **54** wherein said processor circuit is configured to determine a highest bit position in said at least one

20 resultant PNBA in which a bit is set.

56. The apparatus claimed in claim **55** wherein said processor circuit is configured to select as said longest code a code having a sub-combination corresponding to said highest bit position in said at least one resultant PNBA.

25 57. An apparatus for locating next hop information for a packet having a destination address, the apparatus comprising the apparatus claimed in claim **56** in which the destination address is the given code and wherein said processor circuit is configured to locate a position in a

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next hop array associating next hop information with active PNBA bit positions of the search PNBA, by determining a highest numbered bit position in said resultant PNBA and summing all of the active bits in the search PNBA in positions of the search PNBA less than a position with

5   the same number as said highest numbered bit position in said resultant PNBA to produce a PNBA sum and adding said PNBA sum to a value representing a next hop pointer associated with said search PNBA to produce a next hop value identifying said position in said next hop array.

10   58.   The apparatus claimed in claim **55** wherein said processor circuit is configured to determine whether or not any longer matching pre-defined code is encoded.

59.   The apparatus claimed in claim **58** wherein said processor circuit is configured to compare said PNBA mask with at least one search PNBA

15   associated with a search page.

60.   The apparatus claimed in claim **59** wherein said processor circuit is configured to determine a next search page to use to seek a longer matching pre-defined code.

61.   The apparatus claimed in claim **60** wherein said processor circuit is

20   configured to determine a next search page by producing an External Subtree Root Bit Array (ESRBA) mask for each PNBA mask, wherein each ESRBA mask has 2^k bit position where k = the number of bits by which said given code is divided into sub prefixes and a bit position P of said each ESRBA mask is set active according to the following

25   expression:

$$P = \text{associated PNBA mask bit position} - 2^{k-1}$$

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62.   The apparatus claimed in claim **61** further comprising ANDing one of said ESRBA masks with an ESRBA associated with a said at least one of said PNBA masks to produce a resultant ESRBA.

63.   The apparatus claimed in claim **62** further comprising determining a set bit position in said resultant ESRBA in which a bit is set and summing all of the active bits in the search ESRBA in positions of the search ESRBA less than a position with the same number as said set bit position to produce an ESRBA sum and adding said ESRBA sum to a value representing a next page pointer associated with said search ESRBA to produce a next page value identifying a next page to use to continue searching for a longer matching pre-defined code.

64.   An apparatus for locating next hop information for a packet having a destination address, the apparatus comprising the apparatus claimed in claim **63** in which the destination address is the given code and wherein said processor circuit is configured to locate a position in a next hop array associating next hop information with active PNBA bit positions of the search PNBA and sorted according to corresponding to said active bit positions, corresponding to said highest bit position in said resultant PNBA.

65.   The apparatus claimed in claim **59** wherein said processor circuit is configured to determine a next PNBA to use to seek a longer matching pre-defined code.

66.   The apparatus claimed in claim **65** wherein said processor circuit is configured to determine a next PNBA by producing an External Subtree Root Bit Array (ESRBA) mask for each PNBA mask, wherein each ESRBA mask has 2^k bit position where k = the number of bits by which said given code is divided into sub prefixes and a bit position P of said each ESRBA mask is set active according to the following expression:

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P = associated PNBA mask bit position - 2^{k-1}

67.   The apparatus claimed in claim **66** wherein said processor circuit is configured to AND one of said ESRBAs with an ESRBA associated with a current PNBA to produce a resultant ESRBA.

5   68.   The apparatus claimed in claim **67** wherein said processor circuit is configured to determine a set bit position in said resultant ESRBA in which a bit is set active and sum the bits of any previous search ESRBAs in the page to produce an ESRBA previous sum, and to sum the bits of a preset search ESRBA up to the same position as said set

10   bit position to produce a present ESRBA sum and to add the ESRBA previous sum to the ESRBA present sum plus **1** to produce a PNBA-ESRBA indicator representing a next PNBA-ESRBA pair to use for searching.

69.   The apparatus claimed in claim **68** wherein said processor circuit is

15   configured to determine a next page with which said next PNBA-ESRBA pair is associated according to the relation:

$$\left\lceil \frac{r - u - 1}{u} \right\rceil$$

Next page = next page pointer in current page + $\left[\frac{r}{u} \right]$

where

r =   said next PNBA-ESRBA indicator

20   u =   the number of PNBA-ESRBA pairs associated with a page

when

$r > u$.

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70. An apparatus for locating next hop information for a packet having a destination address, the apparatus comprising the apparatus claimed in claim 68 in which the destination address is the given code and wherein said processor circuit is configured to locate a position in a next hop array associating next hop information with active PNBA bit positions of each search PNBA by summing all of the bits of all previous search PNBAs in a page to produce a PNBA previous sum, and by summing all of the bits of a present search PNBA associated *less than the position* with said page up to a position where the bit is set to produce a present PNBA sum and by adding the PNBA previous sum with the PNBA preset sum plus a value representing a next hop pointer associated with the page associated with the preset PNBA to produce next hop array position value identifying a next hop array position in a next hop array at which said next hop information is stored.